514

Convexity and Imageability

Convex Maps and Urban (Space) Envelopes

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ABSTRACT

Urban spaces are defined by degrees of axial and convex extension. Space Syntax research has predominantly emphasized axial lines and maps and considered convexity through isovists and visibility graphs. Axiality emphasizes movement or flow and creates axial maps as two-dimensional networks. Convexity of urban space is aural and shaped by vision and sound in three dimensions. It is represented by convex maps of stretchable polygons (described furthermore by an adjacency scene graph within the polygons) and remain fuzzy conceptualizations because of their property as three-dimensional objects. Kevin Lynch's morphology of imageability and Michael Southworth's soundscapes can be used to create diagrammatic representations of convex spaces as townscape representations. This paper explores the convergence of Space Syntax and imageability, soundscape and townscape theories for analysing three dimensional urban spaces in two dimensional representations. The 'urban envelope' creates an assemblage of building façade and street sections as fronts and empty spaces as voids surrounding one viewshed. The viewshed like an isovist or visibility graph on map depicts convexity, but with an image collage of fronts and voids (surrounding buildings and streets) distorted on a map. The urban envelope is used as an urban design drawing board in a new software for City Information Modelling (CIM) that is under development. This paper aims to inspire synergetic ways to juxtapose morphological and urban design traditions to discuss applications of morphological theories and urban design practices.

KEYWORDS

Convexity, imageability, townscape, envelop distort, urban design

1 INTRODUCTION

Urban space structures differ from one another according to the degree of axial and convex extension of their parts and according to the relation between these two forms of extension (Hillier and Hanson, 1994, p.92). The space structure can be looked at axially, convexly, and in the relation between axial and convex. The systems of axial and convex space can be discussed in terms of their internal configurations, in relation to each other, in relation to the buildings which define the system, and in relation to the world outside that system. The ensemble of axial lines creates two dimensional networks to which movement and flow are the key feature. Convexity is represented with two-dimensional maps of polygonal spaces and a scene graph describing adjacency relations between the spatial elements. Space Syntax research has predominantly emphasized axial lines and maps, and considered convexity through isovists (Benedikt, 1979) and visibility graphs (Turner at al., 2001, 2005; Turner, 2003; see Depthmap software, Turner, 2001). Convex spaces remain fuzzy conceptualizations because it is three-dimensional. Convexity is shaped by audio-visual perception. The buildings act as fronts creating thorny isovists on map, but the convex spaces are experienced as townscapes or continuous succession of environmental and morphological units (Caniggia and Maffei, 2001 [1977]; Purini, 2005)

Kevin Lynch's (1960) morphology of imageability and wayfinding can be used to create diagrammatic representations of convex spaces (on diagrammatic knowledge in urban design see Dovey and Pafka, 2016). Michael Southworth (1967; 2020) has furthermore used wayfinding to map soundscapes in urban spaces. Townscape is a picturesque urban design tradition that uses photographs or urban sketching to capture the visual experience of cities (de Wolfe, 1949; 1963; Cullen, 1949; 1961). This paper juxtaposes Space Syntax with imagability and soundscape theory and townscape analysis to describe convexity of three-dimensional urban spaces with two dimensional representations. Space Syntax research generates two dimensional maps of isovists (Benedikt, 1979) and visibility graphs based on Gibsonian visual perception (Turner at al., 2001, encoding affordances, Turner and Penn, 2002). The urban (space) envelope creates an assemblage of building facades and street sections (as fronts) and open spaces (as voids) surrounding one viewshed. The viewshed like an isovist or visibility graph on map depicts convexity, but with an aural collage of fronts and voids (surrounding buildings, streets, and open spaces) distorted on a map. The affordances are shown visually (building façades with entrances and windows, street spaces with sidewalks, bike lanes, car lanes and so on).

The paper aims to inspire synergetic ways to discuss convergences of Space Syntax, morphological theory, and urban design practices. The urban envelope is used as an urban design drawing board in a new software for City Information Modelling (CIM) that is under development (Stojanovski, 2013; 2018; Stojanovski et al, 2020). The paper is structured starting with theory to discussions about implementations in urban design practices. The following section presents the conceptual background of urban space theories. The third section describes the convergence of urban space theories into the urban (space) envelope. The fourth section discusses the eclectic mix of morphological theories and implications for spatial analysis of convexity and urban design practices concludes the paper.

2 THEORY

Space Syntax highlights spatial interactions and syntactic analysis of settlements (Hillier and Hanson, 1984; Hillier at al., 1987). The settlements are made of spatial elements: closed elements like dwellings, shops, public buildings, and so on, which, by their aggregation define an open system of public spaces, streets, alleys, and squares which knits the whole settlement together into a continuous system. Since this space structure (which can be looked at axially, convexly, and in terms of the relation between axial and convex extension), is the result of the arrangement of buildings, and possibly other bounded areas such as gardens, parks, and other open spaces, it can also be described in terms of how the houses, shops, public buildings, and the like, are adjacent to and directly or indirectly permeable to it. The systems of axial and convex space can be discussed in terms of their internal configurations, in relation to each other, in relation to the buildings which define the system, and in relation to the world outside that system (Hillier and Hanson, 1984, p.92).

Space Syntax introduces a generative syntax model with two concepts. The description of space as a set of syntactic relations that defines a particular space and the synchrony of space in the experiential interactions between axiality and convexity (movement versus adjacency, flow versus location). It highlights a diachronic notion of structure in which structure grew by a stage-by-stage process and represented as a graph and maps of axial lines and convex space. The syntactic relations in the axial and convex maps are analysed in terms of the basic properties of symmetry-asymmetry and distributedness-nondistributedness (Hillier and Hanson, 1984; Hillier at al., 1987). The Space Syntax measures themselves are measures of the graph rather than of the map. Thus the connectivity of each spatial unit, mean depth, or, unique to Space Syntax, integration is calculated in exactly the same way for each type of component (Turner 2007). Space Syntax works with axial lines and visibility graphs based on isovists (Benedikt, 1979) and Gibsonian visual perception (Turner at al., 2001, encoding affordances, Turner and Penn, 2002; visibility-analysis techniques, Turner, 2003) integrating various analytical tools with development of the Depthmap software at University College London (UCL) (Turner, 2001). An isovist is the set of all points visible from a particular vantage point in space with respect to the obstacles and voids in the line of sight within a given environment (Benedikt, 1979). Space is perceived as a set of affordances. Affordances show what the environments offer to the observer (Gibson, 1977; 1986). Isovist is the perceptual framework for orientation in space, and the axial line shows flow affordance in a space (to move along a thorny prospect in the 360 panoramas of the isovists). The appeal of the concept is that isovists are an intuitively attractive way of thinking about a spatial environment because they provide a description of the space from inside, from the point of view of individuals, as they perceive it, interact with it, and move through it (Turner at al., 2001, p. 103).

The analytical tools for convex spaces are under development (Turner, 2001; Osmond, 2011). Convexity is typically represented with two-dimensional maps of convex spaces polygons and a scene graph describing adjacency relations between the spatial elements, but convex spaces are three dimensional and the scene graphs should represent relationships in 3D. The body of the thorny isovist field creates axial and convex extensions from a viewpoint. Axiality inspires movement and flow (and creates tunnel vision in one dimension). Convexity stops movement and inspires aural space observation in three dimensions. The affordances are spatial elements in a scene graph in three dimensions. The vision is not aural, but an aural collage of images. The isovist field is an elegant solution to illustrate potential vistas in two-dimensional Geographical Information Systems (GIS) that are predominately used for spatial analysis, but it fails to represent the aural collage of images (a human observing the townscape and creating a scene graph from spatial elements). Space Syntax, spacemorphology and urban morphology need a perceptual (imageability) turn eclectically revisiting human vision and image-analytical traditions in architecture, urban design, and computational science to formulate representations and develop software for convexity. This paper introduces urban (space) envelopes as possible representation for convexity (enclosure, adjacency, and permeability). The following subsection presents theoretical inspirations for the urban envelope from Lynchian imageability and townscape analyses, perceptual (urban) morphology and typo-moprhology to spacemoprhology and moprhospace (including new conceptualisations and development in computer vision with scene parsing and 3D object recognition). The second subsection of the chapter describes the morphology of the urban envelope. The third subsection discusses links between convexity and scene graphs and reviews literature from generative architecture and morphospace and newer procedural models.

2.1 Imageability and townscape analyses

Kevin Lynch argues that the city is experienced through images, and that city has own image (or series of images) held by its citizens. He conceives the city as adapted spaces and a flow system (Lynch and Rodwin, 1958). The physical form of cities is described by perceptual elements that are revealed to observers: paths, nodes, districts, edges, and landmarks (Lynch, 1960). Paths are the channels along which the observer customarily, occasionally, or potentially moves such as streets, walkways, alleys, and so on. Edges are the linear elements not used or considered as paths by the observer: shores, edges of development, walls, etc. Districts are the sections of the city with two-dimensional extent, where the observer mentally enters inside of and which are recognizable as having some common, identifying character. Nodes are points, the strategic spots in a city into which an observer can enter and which are the intensive foci to and from which someone travels such as break in transportation, a crossing or convergence of paths. Landmarks are another type of point reference, but the observer does not enter within them, they are external. A landmark is usually a rather simply defined physical object: building, sign, store, mountain, and so on. Lynch (1960) developed diagrammatic two-dimensional mental maps with paths, nodes, districts, edges, and landmarks as representations that were further developed by Michael Southworth (1967; 2020) in mapping soundscapes. Donald Appleyard (1969; 1970; 1981) developed representation and methods for structuring cities and analysing interactions between buildings in street spaces. The Lynchian imageability links to townscape analysis. Townscape is a picturesque urban design tradition that uses photographs or urban sketching to capture the visual experience of cities (de Wolfe, 1949; 1963; Cullen, 1949; 1961; Ivor de Wolfe was the pen name for Hubert de Cronin Hastings, the editor of The Architectural Review who advocated for townscape). Townscape analysis is typical executed with sequences of images showing serial vision. Gordon Cullen developed analytical tool and maps with notations about elements in the townscape like space entities, ambiences, point of references, connections, space barriers, levels, proportions vistas (Cullen, 1967).

2.2 Perceptual urban (typo)morphology and morphospace

Morphology is a science about the essence of form (Goethe, 1988 [1817]; Steadman, 1979). Morphological analysis is defined by a hierarchy of three fundamental elements (Figure 1A): streets and their layout, the property structure of plots and their aggregation into blocks, and buildings and land use as it pertains the building function (Conzen, 1960; Moudon, 1997; Whitehand, 2001; Kropf, 2011; 2014; 2018). They follow morphogenetic priorities by reflecting persistence or lifespan of elements that comprise the form of complexity (Whitehand, 2007). Typo-morphology is a branch of urban morphology that defines urban form through types and patterns (including structure, elements, and hierarchies organized in typologies). Typologies are the systematic way to perceive, classify and build the human environment in structuring finding people-site interaction (Muratori, 1967). The spatial practices of any society both structure and are structured by the activity of creating and classifying types (Franck and Schneekloth, 1994). Society creates types (of streets, buildings, neighbourhoods and so on) to simplify communication and promote values (Franck 1994). Types and patterns are ideas (abstractions and theoretical constructs) about houses, buildings, streets, cities and so on produced through observation (detached, terraced, semi-detached house, etc.). Typo-morphology emphasises the reciprocity between architectural types and urban morphology and their perception. The perceptual (the building type as image in dynamical interaction in the townscape as ambient). The physical and structural relationship between an abstract space model (type) and functional urban pattern (urban morphology) connects architectural languages between past and present and ensures urban identity and character over the time. Such diachronic and dialectic relationships are defined as morphology by typology and typology by morphology with the logic of polarities (Hwang, 1994).

Urban design practices and (typo)morphological theory are intertwined. Urban morphology is about inference and interpretation of type; urban design is about invention of types and intervention using type (Marshall and Çalişkan, 2011). Urban designers use typologies to analyse and design cities (Caniggia and Maffei, 2001 [1977]; Hayward and McGlynn, 1993; McGlynn and Samuels, 2000; Talen, 2009a; Hayward and Samuels, 2018; Talen 2018). They also lean on photographs, building elevations and street profiles to describe types of edifices and streets (Southworth and Ben-Joseph, 1997; Southworth 2005) and they typically turn typologies into design or Form-Based Codes (FBCs) (Ben-Joseph, 2005; Carmona et al, 2006; Walters, 2007; Talen, 2009b; 2013; Marshall, 2011) following morphological methods. Southworth (2005) showcases an exemplary methodology, mixing images and illustrating diagrammatic relationships to describe patterns of evolving typology of shopping malls as building complexes. Photographs, urban sketches, building façades or street profiles are perceptual representations used by urban designers to define building or street types in contrast to maps and plans (Figure 1B). Perceptual urban (typo)morphology creates a convergence of perceivable representations with (urban) morphological cognition of cities (the hierarchical structure). Humans perceive townscapes as imagery of frontages and surfaces that gently invite through its (typo)morphology. These inclusive spaces reassure when adjacent to an enveloping perimeter. On the contrary, most of open spaces that lack enclosure tend to be avoided.

The urban spaces are typically represented through images (photographs. urban sketching and digital imagery), plans and maps, or topologies (Alexander, 1964; Steadman, 1973, 1979; 2014; Hillier and Hanson, 1984; Hillier at al., 1987). Spatial analysis utilises available computational methods and representation from GIS to create axial and convex maps. GIS takes a top view to create a raster or vector representation of the Earth surface (Figure 1D). Space Syntax uses polygons (supported by a scene graph) to represent convex spaces on map. Convexity is a perceptual quality between move (entering a flow) and stop (observing spaces). It needs a human vision perspective on surrounding buildings. Figure 1C3 and Figure 1D2 show a diagrammatic urban (space) envelope distort of 3D (within view as assemblage or collage of front views and images describing aural soundscapes). The urban (space) envelope was developed to inspire advancement from GIS to 3D spatial media and CIM (Stojanovski, 2013b, 2018; Stojanovski, et al., 2020). The aspirations for the applied use of 3D technologies have yet to be mainstreamed (Gil, 2020; Kitchin *et al.*, 2021). There are developments for convergence of computer graphics and computer vision in developing a data structure that integrates images, scene graphs and 3D geometry (discussed by Shapiro, 1979; Eklundh, and Kjelldahl, 1985). GIS uses point, lines, and polygons following a tradition of computer graphics and CAD, whereas computer vision does image analyses based on human vision (Gibson, 1950; 1986).

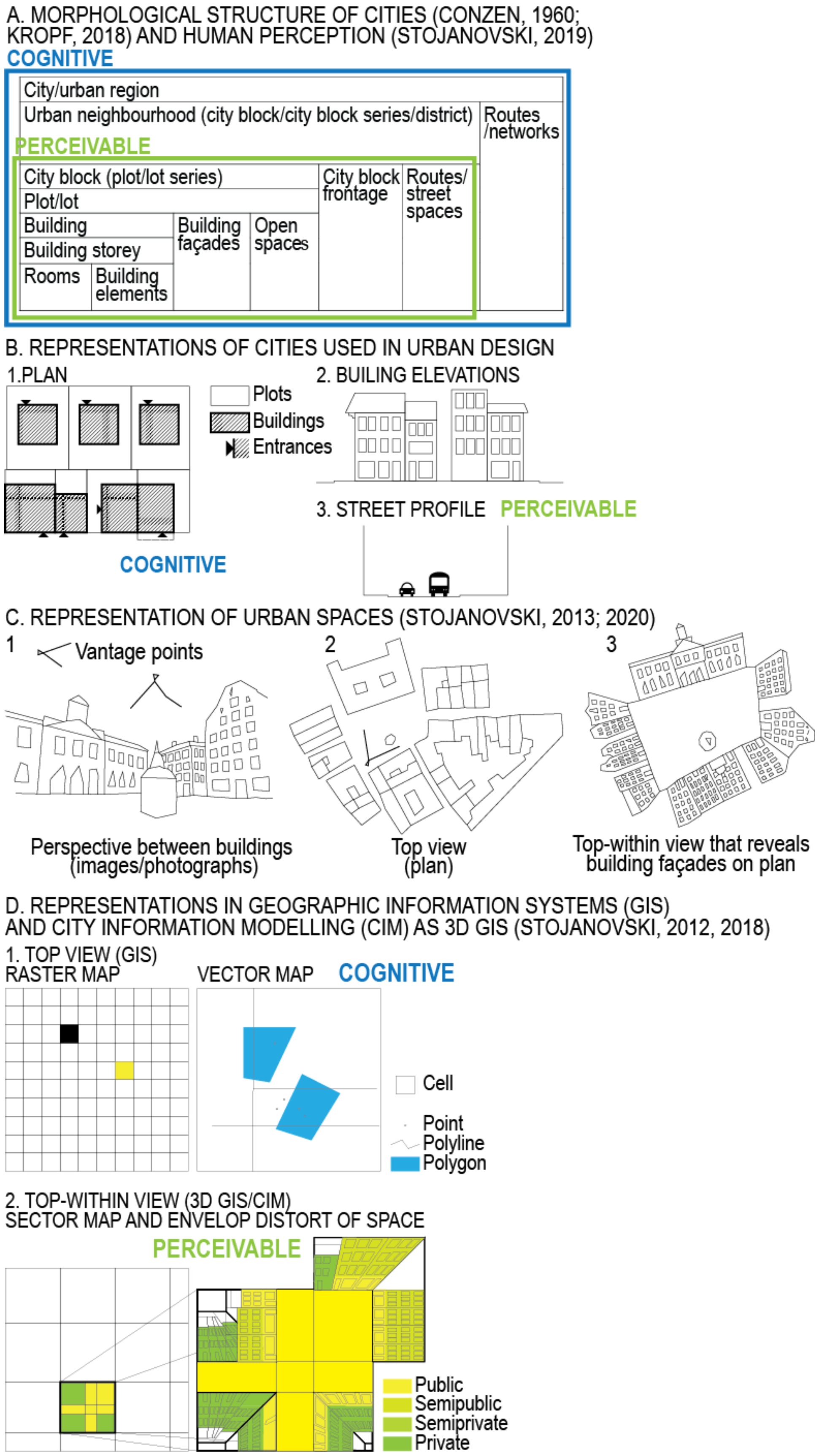

Figure 1: Representations of urban space

The GIS data structure includes geometric elements and shapes as classes defined by integers (as geospatial coordinates) and linked to a database with integer and string variables (raster data is integrated in the map as array of integers). Computer vision detects edges and objects, parses scenes and recognizes objects to create 3D representation and scene graphs (Dickinson *et al*., 1990; Fidler *et al*., 2012; Zhou, *et al*., 2019). In computer vision the scene graphs are preprogramed, but the graph data structure can connect to GIS via theories about generative algorithms, morphospace and procedural models.

2.3 Spacemorphology, morphospace, and graphs of convexity

The morphological structure (as perceptual and cognitive elements shown on Figure 1) can be understood as a generic scene graph of convex spaces. The scene graphs have been used to describe spatial knowledge and design context (sets of elements in a pattern, Alexander, 1964). Steadman (1973) demonstrates how graphs may be constructed of architectural arrangements, considering relationships between architectural units (such as rooms or corridors), although the original concept dates back further (for example, see Ole, 1963; March and Steadman, 1971; Turner at al., 2001, p.103). There is morphological research on generative aspects of archetypal buildings and representations, such as the concept of morphospace (Marshall, 2015; Steadman, 1998, 2014; Steadman and Mitchell, 2010). Graphs are inversely used in design theory for automating design and generative models (Mitchell, 1977; 1990). Following upon that tradition, procedural models virtually reconstruct cities by applying generative algorithms as scene graphs. They use hierarchies of urban design and architectural elements and sets of rules to create buildings and urban environments in 3D (Parish and Müller, 2001, Müller et al., 2006; Wonka et al., 2003; Vanegas et al., 2010; 2012; Besuievsky and Patow 2013). The procedural models generate 3D from GIS data based on scene graphs (Biljecki m fl., 2016; 2017; Rogla et al.,2021). The scene graphs in procedural modelling follow the generic morphological structure of cities (Figure 1A). Computer vision detects edges and objects parses scenes and recognizes shapes of objects to create 3D representation and scene graphs (Dickinson *et al*., 1990; Pizlo, 2008; Fidler *et al*., 2012; Dickinson and Pizlo, 2013; Zhou, *et al*., 2019). The scene graphs are (spatial) knowledge graphs or semantic networks that like in procedural modelling are preprogramed and usually aligned to the generic morphological structure of cities. The scene graphs are (spatial) knowledge graphs or semantic networks that need a data structure that connects to GIS (in computer vision the scene graphs are preprogramed). The GIS data structure includes geometric elements and shapes as classes defined by integers (as geospatial coordinates) and linked to a database with integer and string variables (raster data is integrated in the map as array of integers). Following the computer graphics tradition, GIS uses point, lines, and polygons whereas computer vision does image analyses based on human vision (Gibson, 1950; 1986). Even though there are earlier debates on converging computer graphics (thus GIS representations) and computer vision and images that integrate human vision, 3D geometry and scene graphs, there is no such data structure (Shapiro, 1979; Eklundh, and Kjelldahl, 1985). Typically, the images are raster graphics and the 3D geometry is vectorized in 2D (Figure 1D).

3 CONVEXITY, ENVELOPE DISTORT AND URBAN (SPACE) ENVELOPES

Convexity in Space Syntax describes enclosure, adjacency, and permeability. Convexity is represented with two-dimensional maps of and a scene graph describing adjacency relations between the spatial elements. Convex spaces are mapped as polygons (often rectangles Hillier and Hanson, 1984; Hillier at al., 1987), expanding axially or normal to the axial line (convex extension) depending on the closed elements (Lynchian edges that create barriers with different grades of permeability, from solid buildings to permeable fences, building façades and so on). Enclosure, adjacency, and permeability are shaped by audio-visual perception (Figure 2). The convex spaces have one or more viewpoint and the surrounding closed objects (dwellings, shops, public buildings, and so on) are frontages. The convex spaces as polygons on a map represent the body of thorny isovist start in two dimensions (typically analysed as a visibility graph). Axiality inspires movement and flow (and creates tunnel vision in one dimension). Convexity stops movement and inspires aural space observation in three dimensions. The convex spaces are Lynchian nodes (for example at intersections, squares and so on, where convex extension prevails over axiality) or Lynchian paths along axial lines (for example on street segments where axiality dominates). Convexity is experienced in enclosed three-dimensional spaces and needs adequate representations. A key issue is that the open spaces per se are weakly characterised, as mere empty space across which sight lines establish the urban relations. Urban voids are eventful and rich in the relations that they maintain with the surrounding objects. Many of these relationships are largely conceptual and symbolic in nature, but as such they have a material manifestation (Torres García, 2017) that these representation methods fail to grasp. Streets offer a much more complex experience than simple flux vectors. The complexity of the juxtaposed traffic modes, or the cadence of the façades and side-streets along their limits become greatly simplified.

Convex spaces remain fuzzy conceptualizations because of their property as three-dimensional objects and their conversion to two-dimensional convex maps. To propose alternative for convex spaces as polygons on a map, the urban (space) envelope develops a representation that mixes frontages with plans. It eclectically combines theories and representations inspired by imageability and wayfinding (Lynch, 1960; Southworth, 1967; 2020; Appleyard, 1969; 1970: 1981), townscape analyses (de Wolfe, 1949; 1963; Cullen, 1961) and urban morphological and typological research (Conzen, 1960; Caniggia and Maffei, 2001 [1977]; Moudon, 1997; McGlynn and Samuels, 2000; Kropf, 2011; 2014; 2018). Imageability alludes to the ability of cities to embody images and to be experienced through (series of) images (Lynch, 1960). Morphological analysis is defined by a hierarchy of three fundamental elements: streets and their layout, lots and their aggregation in blocks, buildings and land uses as building utilisation (Conzen, 1960; Moudon, 1997; Kropf, 2011; 2014; 2018). Urban designers use photographs, building façades and street profiles to describe types of buildings and streets (Southworth and Ben-Joseph, 1997; Southworth 2005). The townscape analysts like the urban morphologists, define the urban character as relationships between the morphological elements but with emphasis on the visual experience of cities within the *field of vision* (Cullen, 1961). To create a visual experience of two of the three fundamental elements (streets and buildings). The urban envelope unwraps the projections of the urban space and reveals building façades and street profiles on plan. The three-dimensional to two-dimensional diagrammatic projection creates an urban experience of a flâneur standing on a street corner and observing the townscape. The urban envelope allows an analysis of the interaction between the streets and squares with the surrounding buildings as fronts (street frontages and building façades) and voids (axiality of streets and horizon of open space). Appleyard, 1981, shows analytical background to analyse interactions between buildings. The urban façade becomes an additional fundamental element of urban form on the plan (complementing the building as townplan element).

Figure 2 dissects and represents the elements of two city block morphological conceptualization (see Tiesdall and Adams, 2011, p.95, on parcelisation strategies). The standard masterplan follows a British/German tradition in urban morphology of town plan elements (Conzen, 1960). In this tradition the city is built by blocks of plot series surrounded by streets (Figure 2A1). The Italian morphological tradition analyses the city as an organic system of routes and streets (Figure 2A2) and typologies of buildings (including building plans and façades, Caniggia and Maffei, 2001 [1977]). The city is perceived as a townscape through images such as drone perspective (Figure 2B2) or as distorted top perspective revealing the building façades (Figure 2B2). The buildings and plots adjacent to routes and streets create a townscape as convex spaces that has fronts (from public to private buildings, from blocked views to permeable fences and façades and open spaces).

Figure 3 illustrates conceptually the urban envelope depending on the space: as street segment in Figure 3A, street intersection (node) in Figure 3B or square (public space surrounded by buildings) in Figure 3C. The urban envelope as a design board for urban designers is complementary to the master plan. It is used as a conceptual background for an interactive digital design board in the CIM software that is currently under development. Computational technology allows the visualisation of townscapes and creates diagrammatic transformations automatically and from GIS data. The CIM software will utilize cadastral maps from GIS and masterplans to create urban envelopes depicting townscapes procedurally in interaction with actors and stakeholders. The building elevations and design elements of the buildings and the street profiles with assigned streets spaces for pedestrians, bicycles, cars, buses, trams, trains, and so on. can be interactively changed in CIM software or they can be printed on paper to design or discuss townscapes for specific street segments.

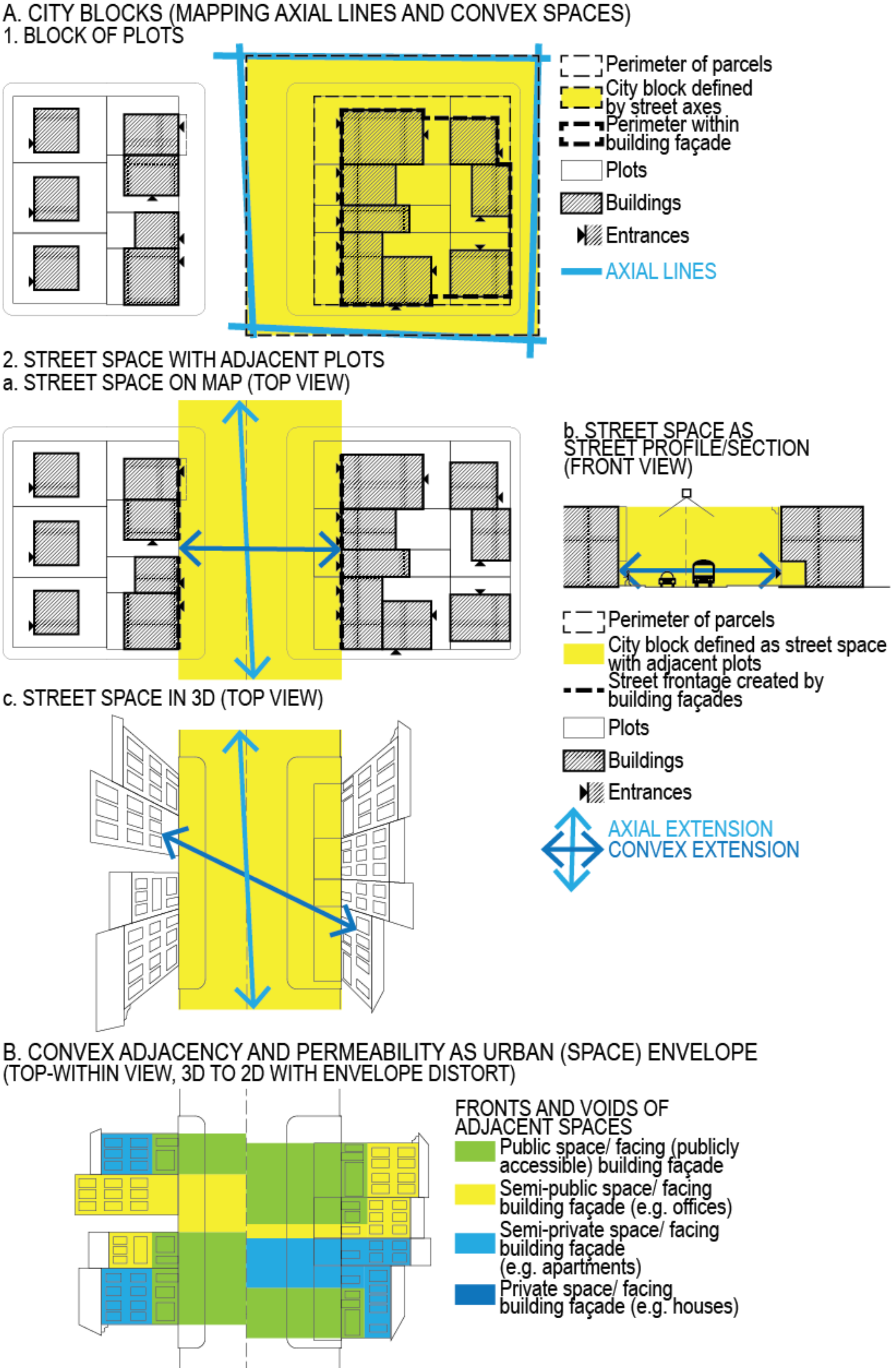

Figure 2: Convexity with urban space envelope showing permeability as fronts and voids

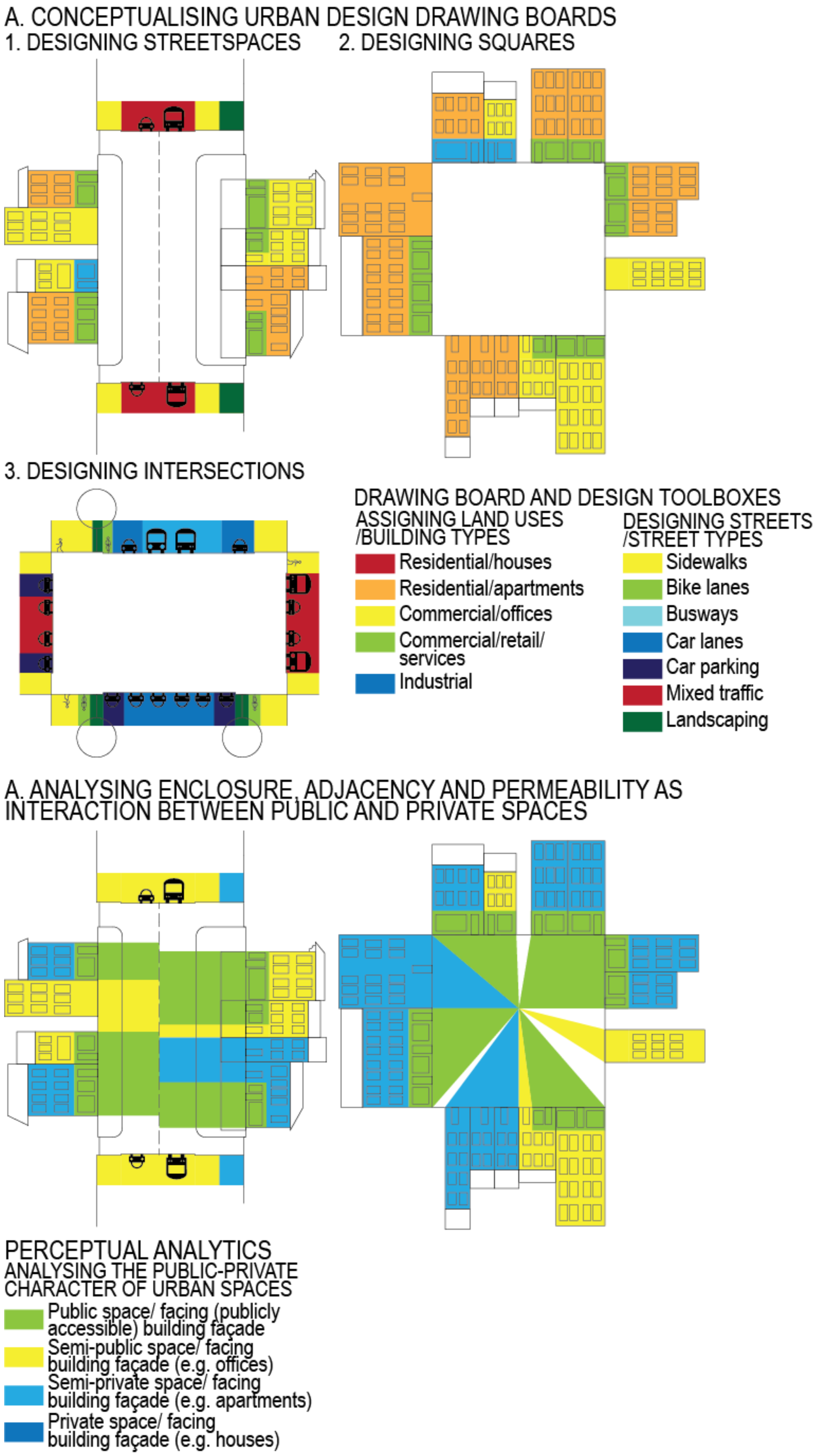

Figure 3: Convexity with urban space envelope showing permeability as fronts and voids

4 DISCUSSIONS AND CONCLUSION

This paper presents a theoretical background and practical application of the urban envelope as representation for convex spaces in a future 3D GIS and CIM. The two-dimensional urban envelope reveals building façades that allow the experience of a three-dimensional perception of townscapes and analyse the interaction between the streets and squares with surrounding buildings. Building façades are typically used to analyse townscapes by urban designers (Appleyard, 1981; Talen and Jeong, 2019) and historically they can be traced to the 18th century. But the difference with the urban envelope is the use as a (digital) design board with a design toolbox of building façades with windows and doors, building storeys with various land uses, street profiles with transportation modes, etc. The convex spaces are described by graphs and the arrangement of these spatial elements creates a scene graph in 3D (represented by perceivable images). The representation allows working with scene topology, element typologies and FBCs, design codes and guidelines and the future integrate in a graphic representation of (collaged) images that integrate 3D geometry and scene graphs (discussed by Shapiro, 1979; Eklundh, and Kjelldahl, 1985) as context-based computer vision. Convexity is typically represented with two-dimensional maps of convex space polygons and a scene graph describing adjacency relations between the spatial elements, but convex spaces are three dimensional and the scene graphs should represent relationships in 3D. The body of the thorny isovist field creates axial and convex extensions from a viewpoint. The isovist is an elegant solution to illustrate potential vistas in two-dimensional GIS that are predominately used for spatial analysis, but it fails to represent the aural collage of images (a human observing the townscape and creating a scene graph from spatial elements). It also excessively simplifies the qualitative nature of urban open spaces, the manner, and the degree to which what appear to be voids on the map are eventful, distinct, and determined by the surrounding urban features. Moving away from analysis of spaces to image analysis also links to traditions in computer vision. Computer technology and procedural modelling allows the visualisation of townscapes and creates diagrammatic transformations automatically from GIS data and cadastral maps. The prospect of integrating images brings possibilities to incorporate newest image analyses in computer vision (scene parsing, 3D object recognition, see Fidler *et al*., 2012; Zhou, *et al*., 2019).

Space Syntax, spacemorphology and urban morphology need a perceptual (imageability) turn eclectically revisiting human vision and image-analytical traditions in architecture, urban design, and computational science to formulate representations and develop software for convexity. The urban (space) envelope method combines Lynchian imageability (and Southworth's aural soundscapes), Cullen's townscape analysis, and typologies to represent convex spaces in 3D. This will help not only advance Space Syntax but will also create bridges between the different morphological schools and approaches furthermore creating new bridges to computer graphics and procedural modelling and computer vision and image analyses.

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